Business Process Modelling in Production Logistics: Complementary Use of BPMN and UML

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Abstract: This paper investigates the suitability and sufficiency of BPMN language in business process modelling. Production logistics system is modeled at the highest domain level using case study in car component industry to examine the language in every aspect. Modelling is carried out in a modular basis for three main sub-systems generally using BPMN 2.0. Complementary use of other modeling tool to cover all the critical flows of objects and associate data in modeling was seen necessary and addressed using UML activity diagrams employing the specific capability of modeling the material flow and semantics. Modeling the flow of objects provides the comprehensive perspective of the whole system and fulfill the need of capturing all undepicted object flows as well as processes and data which may not be sheerly covered using the BPMN. The proposed models provides great beneficial referentiality for modelers, analysts and actual practitioners of logistics activities. The significant explanatory description and strategy are the key feature of the paper to follow using state-of-the-art modeling tool of BPMN 2.0 and UML.

Key words: Computer-aided systems - Production logistics - Business process modelling - BPMN 2.0 - UML - Modelling techniques

INTRODUCTION

Business Process Modelling (BPM) as the main core in Business Process Management is the activity of representing the processes of an enterprise [1, 2] either at its current state or to what it should become [3]. Nevertheless, in last few years a must need for an expressive and easy-understanding business process modelling language suitable for all range of users emerged. At the present, there are several modelling languages which define the basic elements for constructing business process models. The mains are in historical order:

- Petri nets (PN) [4].
- Event-driven Process Chains (EPCs) used within ARIS framework [5].
- UML Activity Diagrams, the process modelling language of UML [6].
- Yet Another Workflow Language (YAWL) is built on the workflow pattern analysis [7, 8].
- Business Process Execution Language for web services (BPEL) to model executable processes [9].
- Business Process Modelling Notation (BPMN) to describe the business processes using notations standardized by OMG [10].

This paper aims to contribute in investigations on suitability of BPMN as the latest prominent language in constructing a business process model [11]. Even though BPMN tends to be practiced and more applicable at the very highest level description of business operations [12, 13] but there is absolute shortcoming in dealing with object flow semantic and its essential insights that is meant to provide for the system analysts and developers. This problem is much more noticeable when modelling the processes dealing with material flow instantiation which information are not only sometimes attached to the objects but also are changed and modified with delays, locations and transformations which cannot be fully addressed only by BPMN. To provide a real world example the Production logistics as a complex cooperative
and systematic group of activities is fully examined which highlights the incapability of modelling the object flow using solely the BPMN and it is revealed that the problem can only be addressed with complementary use of techniques.

Consequently, this paper provides a two-fold contribution. First, we analyse a large set of actual business processes through case study. Through modelling with BPMN we examine the whole syntax and semantics in covering all modelling requirements for the system. The requirement for a complementary use of BPMN 2.0 and UML activity diagram to respond to the problem is highlighted and discussed. Second, the generic proposed model designed for logistics activities in a SME environment and the significance of the study on implication BPMN 2.0 is represented. UML activity diagram is employed to represent the material workflow system which is dramatically seen required at business analyst and system architect perspectives of the model applications. The presented business process model of production logistics using a case study in SME environment is considered as great beneficial example for business modellers and analysts as well as actual practitioners of logistics activities in supply chain. In addition, the significant explanatory description with easy-to-understand strategy and technique to accomplish the process and material flow are key promising feature of the paper to follow on modelling identical cases and systems.

The reminder of this paper is structured as follows. The next section reviews the literature over related researches for BPMN on importance and sufficiency of the language. Next methodology is introduced. Assuming the reader has basic understanding of the two employed modelling languages, a brief introduction is provided. Production logistics analysis is carried out and is followed by identification and classification of modelling requirement. Next, the development of business process model is discussed for three main modular systems basically with BPMN and is elaborately completed with UML activity diagram. Eventually, concluding remarks and future research directions are provided.

Related Works: There are several researches over the importance, quality and suitability of the modelling languages. Since, business process modelling and designing is a complex and, thus, error prone task [14] a large number of methodologies for modelling and analysing business process has been emerged. Many of these methodologies present rich design environments lacking accurate conceptual perception and the others have clear conceptual foundation but lacking graphical expressivity [15]. Both experts in Business Engineering and Information Technology have concluded that successful systems start with an understanding of the business processes of an organisation. IT solutions in many ways can facilitate all the different phases of understanding and capturing the processes [13, 16, 17]. At daily scheduling and should provide the benefits at time-activity it will provide

Furthermore, business processes are a key factor in integrating an enterprise [18]. Conceptual modelling of business processes is deployed on a large scale to facilitate the development of software that supports the business processes and to permit the analysis and re-engineering to improve them even in daily basis activity [19]. Information models use business process models and associated data resources [20, 21]. If the processes are well described, designing data resources is an easy task [22]. In other words, if the business processes are not in line with the information system, the system implementation is unlikely to create any benefits [23, 24]. In fact, Process-aware information systems typically involve various kinds of process stakeholders. That, in turn, leads to multiple process models that capture a common process from different perspectives and at different levels of abstraction [25]. This clearly indicates at designing a system, one should plan for quality BPMs as the premier requirement to achieve a successful software development for the system [26].

There are several useful proposed techniques and patterns to follow. Mendling et al. [27] suggests a set of seven guidelines to construct a quality business process model; Gunasekaran and Kubo [28] provide guidelines on selecting modelling tools/techniques associate to areas in which re-engineering should be carried out and Reijers et al. [29] suggests syntax highlighting as helpful and sense-making technique at modelling process. On selecting modelling language, Muehlman and Indulska [30] provides users with the highest representation power while suffering an amount of construct overlap; Where Rajala and Savolainen [31] approach is basically customer-oriented using QFD as source data and suggests IDEF0 as process modelling. Luo and Tung [32] propose a framework base on modelling objectives, Mentzas et al. [33] technique is based on workflow
system approaches and Roorda et al. [34] propose conceptual framework outlined with mathematical notations generally based on roles of actors.

Many researches have been conducted to evaluate the sufficiency and capabilities of modelling languages. Strembeck and Mendling [21] declare insufficiency of any modelling language element corresponding to integration of processes and role-based access control (RBAC); Whilst Almeida et al. [35] extends semantics foundation for role-related concepts and understandings of actors. Base on SAP reference model inputs, Mendling et al. [36] provides empirical evidence of how many errors can be expected in process modelling using EPC.

Several researches advocate the advantages and sustaining applications of using BPMN in various domains [30,37,38]. Despite BPMN, many of the conventional languages do not lend themselves to automatic analysis, thus their pragmatic quality is hindered. For example, UML or EPC models often translated into Petri net for analysis and simulation [39, 40].

In contrary, some other researches focus on deficiencies of BPMN and propose solutions. Wong and Gibbons [41] findings indicate ambiguities in BPMN semantics and describe two formalisations of the notation and also how to apply the notation to workflows that are normally beyond BPMN scope. Wohed et al. [2, 42] evaluate BPMN using workflow patterns as an analysis framework in control flow, Data and resource patterns revealing more problems in later areas. Some other issues are highlighted by Dijkman et al. [43] in cases with multiple start events, process instance completion, exception handling of multi-instance sub-processes and Or-join gateways. Proposing visual query language of BPMN-Q and like Reijers [29] highlighting erroneous parts of diagram by Laue and Awad [44] is another attempt to address the possible problems and errors in dealing with the sequence flow semantic and also identifying violations in business rules in BPMN. Given the scope of this paper, we are unable to provide a complete listing of many papers on suitability of using BPMN in recent years but to the best of our knowledge there is no active example of a research to highlight the issues on object flow semantic at using BPMN.

**MATERIALS AND METHODS**

Basically, we examined the BPMN language with a real-world practical example in industry to recognise and highlight the problems and provide the requirements and solutions. In order to do this, a twofold method was followed: a) literature research to investigate the theoretical part of language and b) a targeted industrial system. Next, a brief introduction of the two used modelling languages are introduced and followed by analysing the production logistics activity. Further, identification and classification of BPM requirements for the system is discussed which is followed by explanatory development of production logistics business process models.

**BPMN:** BPMN is to provide a standard notation for business processes that is readily understandable for ranging from the business analysts in early phase of system development who sketch the initial drafts of the processes [43] to the technical developers responsible for actually implementing them and finally to the business staff deploying and monitoring such processes [45].

Inspired by UML Activity Diagrams, BPMN 1.0 was released in 2004; and adopted as OMG standard in 2006. However, BPMN 1.1 released in 2008 introduced a UML Class Diagram description of the notation to give a better formalization with no defined meta-model like what there is for UML yet. BPMN 1.x has four categories of graphical elements to build diagrams: Flow Objects, Connecting Objects, Swimlanes and Artifacts. Flow Objects represent all the actions consisting: Events, Activities and Gateways. Connecting Objects provide three different ways of connecting various objects: Sequence Flow, Message Flow and Association. Swimlanes have two elements to group other elements: Pools and Lanes. Artifacts are used to provide additional information about processes concluding: Data Object, Group and Annotation [1, 46].

BPMN 2.0 released in August 2009 was improved by formalizing the execution semantics for all elements in BPEL. Defining a meta-model and diagram type definition to support interchange formats like XMI and XSD with a very wide collection of new elements and constructs is now available in BPMN 2.0 in respect to communicate analytically through diagramming or to model the system for execution [10]. Since BPMN is generally designed with the aim of high-level modelling, they need to be refined into BPEL processes prior to execution for instance. The rationale behind is that the BPMN will be used by domain analysts whose goal is not to produce a system implementation, rather a set of requirements to be generated for various applications such as IT analysis and software development. In the other hand, UML activity diagrams also have the capability to model the
flow of physical Objects in modelling which is required in enterprise workflow system analysis. Comparison between modelling methods has been carried out by several researchers [2, 47, 48]. Figure 1 illustrates the summary of BPMN 2.0 graphical elements.

**UML Activity Diagram:** The UML covers five major aspects at process modelling, namely (1) actions and control flow, (2) data and object flow, (3) organizational structure, (4) interaction centric views on business processes and (5) system-specific process models used for process enactment [49]. The basic building block of a process description in UML is the activity. An activity is a behaviour consisting of a coordinated sequencing of actions; and is represented by an activity diagram. UML Activity diagrams are the fundamental tool for process modelling through integrating the control flow concepts and constructs with the object flow. Activity diagrams visualize sequences of actions to be performed including control flow and data flow. An overview of the basic and some advanced elements of the activity diagram notation are introduced at Figure 2.

**Analysis of Production Logistics:** The scope and the role of logistics have undergone significant changes as well of which that logistics no longer plays only a supportive role in functional areas, nor is it only confined to transportation and warehousing [50, 51]. Logistics as the management of the flow of goods, information and other resources in supply chain encompasses the integration of information, transportation, inventory, warehousing, material handling, packaging and security [52, 53]. Responsive logistics system as the significant value-adding channel of time and place utility all along the supply chain is severely dealing with workflow management system [54].

Cooper et al. [55] encapsulates the widened scope and purpose of logistics management and divides it into three constituent elements: procurement logistics, production logistics and distribution logistics. Since the “procurement logistics” of one is the “distribution logistics” of the preceding link, logistics management only can be perceived as two classes: external and internal logistics (i.e. production logistics) [56]. Internal good flows within a plant include inventories of raw materials and parts, work-in-process and finished products.

Moreover, Logistics is a process-oriented business constituting numerous processes linked together to perform different logistics operations [57]. In recent years, researchers have tended to explore processes from a managerial perspective, concentrating on the classification of business processes [58] and data, information and knowledge management within processes [59]. Modern logistics management relies heavily on access to accurate and timely information [60]. Hence, information is clearly a valuable logistics resource. The importance of the flow of information in logistics channels has been recognized alongside that of material flow [61]. Therefore, to enable the best system adaptation practices within the logistics process to be used, the characteristics of logistics processes and the information related to this should be examined and identified.

Several researches have carried out the study to analyse the logistics system and database design methodologies for integrated information systems [22, 62-64]. However, there are very a few reference models in applications of logistics information systems area but there is not a comprehensive or standard representation of logistics business process modelling or analysis required at the early stage of the system development [20, 65-67]. Therefore, to design a beneficial and appropriate information system, the analysis of the business processes is seen as very crucial prerequisite task [62, 68, 69].

**Identification and Classification of Bpm Requirements for Logistics System:** The literature review on BPM and the case observation and data-gathering on car component industry specifically on production logistics section are used to identify the modelling requirements. Combination of make-to-order (MTO) and make-to-stock (MTS) for a wide variety of more than two hundred different kinds of metal and plastic washers with different sizes and shapes at a large volume at every production plan has been recognized as the case production system. Different kinds and models of rolling, cutting, pressing, de-burring and coating machines and devices are set and laid out to cover such amount of production order basically mostly in cellular style design. Through a total of 56 employees including managers and workers all production processes been carried out within the company while shipping methods been performed either with company itself or through x-party logistics. Through some customer-based official agreements most of the orders are made by three car companies in a rather frequent and arranged seasonal basis; however the company also manufactures products to sell to the market by retailers. Purchasing raw material is generally made through regular suppliers unless with bidders base on quality standards, instructions and company regulations.
Quality control and plan is perfectly accomplished aligned with instruction and sets compatible with ISO 9001 standard elements audited regularly to maintain the compromised factors mentioned in customer agreements. Base on a close observation and study of the case, there have essentially six individual domain sub-systems concluding Order (O) and Shipping (S) sub-systems as outbound logistics and Production (P), Quality (Q) and Inventory (I) systems as inbound been classified. Table 1 illustrates the relationship between identified roles and the systems which are demonstrated as pools in the model. Based on this introduction, modelling the P sub-systems is discussed in next section. Detail procedures and operation specifications of inbound logistics in lower levels are not elaborated to preserve the referential capability.

Development of Production Logistics BPM

Modelling Production System - Explanatory Modelling Technique: Production BPM represents how the work order is fulfilled as responding to the received customer order at its highest domain level. Sales and Quality Dept. are identified as black box lanes; Manufacturer as abstract pool; Production Dept. and Shop floor as lanes. Upon recognition of responsive roles, the next step is to map out the sequential flow of processes through connecting them from a start event up to an end event using happy flow technique as it is shown in Figure 3. P is triggered by Work order “Start” event message from Sales department. “Embedded” sub-process of PP requirement followed by Production planning “Embedded” sub-process leads to the Updating production plan system task. Through registration into the system the production plan is sent to Shop floor, Quality Dept. and Warehouse by Issue production plan “Send” task terminating with a “Message” end event.

Production plan is received in Shop floor and after a while upon “Receive” required resources task event from Warehouse the operation process will be setup with “Embedded” sub-process. Operating process sub-process with “Multi-instance parallel loop” is made on items in a defined size of lots inside the allocated production routings followed by “User” task of Check for process progress status to check for any other remaining operating process required to be performed onto the items in lots. This is shown by All processes are done “Data-based exclusive decision” gateway with a Yes control flow meaning the operation process is ended and followed by Sending goods to warehouse “Send” task and “Message” end event of Work order fulfilled.

Fig. 1: Summary of BPMN 2.0 elements

Fig. 2: Overview of UML AD notations
Fig. 3: Business process model of Production System (P) in first happy flow

Fig. 4: Expanded sub-processes at Figure 3: (a) PP requirement; (b) Production planning; (c) Setting up operation; (d) Operating process.

Table 1: Domain roles of high-level logistics business process system

<table>
<thead>
<tr>
<th>Role</th>
<th>Property</th>
<th>Related system</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer</td>
<td>Black box</td>
<td>(O), (I), (S)</td>
<td>Place work order and receive the finished order</td>
</tr>
<tr>
<td>Supplier</td>
<td>(O), (I)</td>
<td></td>
<td>Regular provider of raw material/outourcing parts</td>
</tr>
<tr>
<td>Bidder</td>
<td>(O), (I)</td>
<td></td>
<td>Random Provider of raw material/outourcing parts</td>
</tr>
<tr>
<td>3PL</td>
<td>(S)</td>
<td></td>
<td>Provide transportation and some other logistics outsourcing services</td>
</tr>
<tr>
<td>Manf.</td>
<td>Abstract</td>
<td>(O), (P), (Q), (I), (S)</td>
<td>Produce /fabricate or fulfill the work order</td>
</tr>
<tr>
<td>Sales Dept.</td>
<td>Manf. as parent</td>
<td>(O), (P), (Q), (I), (S)</td>
<td>Place to receive work orders from customer and place purchase orders to supplier or bidder and place logistics service order to X-parties</td>
</tr>
<tr>
<td>Production Dept.</td>
<td>Manf. as parent</td>
<td>(P), (Q), (I)</td>
<td>Place to plan, design and management of production</td>
</tr>
<tr>
<td>Quality Dept.</td>
<td>Manf. as parent</td>
<td>(P), (Q), (I)</td>
<td>Place to check, control, evaluate, test and quality control</td>
</tr>
<tr>
<td>Shop floor</td>
<td>Manf. as parent</td>
<td>(P), (Q), (S)</td>
<td>Place to produce parts, items and final products through production operation</td>
</tr>
<tr>
<td>Warehouse</td>
<td>Manf. as parent</td>
<td>(Q), (I), (S), (O)</td>
<td>Place to store/retrival the parts, items and final products</td>
</tr>
</tbody>
</table>
Figure 5 illustrates above mentioned sub-processes at the expanded mode. Production planning sub-process contains a number of sub-processes within it and the “Fork/Join” gateways demonstrate the output result of the sub-process may or may not be used into another concurrent sub-process. Operating process sub-process is a parallel multi-instance loop due to the defined routings in a given production line and to show the diversity of the works in progress (WIP) illustrated at Figure 4(d). Operation process task as normal “Loop” type demonstrates that one kind of production operation is performed on one or many (i.e. a lot/batch) semi-finished product.

Next, alternative paths, exceptions, activities and required artifacts are added into the happy path model as it is shown in details in Figure 5. Quality department triggers the “Compensation” start event base on decision made for produced faulty products. Re-production requirement is the next identified sub-process which illustrated in more detail at Figure 6(a) and is pointed toward the “Attached Compensation” intermediate trigger at Production planning sub-process to cover the shortage generated at fulfilling work order through a new compensating production plan. OPC generation is the next new collaboration sub-process managed by Production and Quality departments which is concurrently performed.
with Updating production plan task. Figure 6(b) illustrates the tasks to be done at Production department division. Additional task of Moving WIP to next station is identified at the alternative path of No from All processes are done “Data-based exclusive” gateway to “Inclusive merge” gateway. Figure 7 provides additional details over every activity described in the modelling process.

**Workflow Modelling with UML ADs - Physical Object:**
Next, the complete scenario of material transmission and transformation up to the finished goods using the capability of workflow modelling with UML activity diagrams emphasizing on physical object flow is discussed. The workflow meta-model of WIP using UML activity diagram is explained. Send production plan sendSignalAction at Production department is received by Receive production plan acceptEventAction at Warehouse, Shopfloor and Quality departments. At Warehouse Retrieval/picking action is executed using Production plan data object node. Required resources object tokens are retrieved from Stored items <<centralBuffer>> object node through Required resources input pin with {stream} parameter and places tokens at Resources output pin node with [Retrieved]
status and with \{stream\} parameter. Issue to production action consumes all [Retrieved] tokens and with using PP detail and Resource details information inputs from Production plan and Inventory \(<\text{datastore}\>) object nodes and puts [lotted] Resources at output pin node with \{stream\} parameter and provides Issued resources list data object node as outputs. Update inventory system action consumes Issued resources list data object and registers the records and relations into Inventory \(<\text{datastore}\>) and the flow is ended with a flow final node as it is shown in Figure 8.

Setting up operation activity at Shopfloor consumes all [Lotted] Resources and places [Allocated and coded] Resources at output pin node which is transferred at WIP lot [Coded] \(<\text{centralBuffer}\>) object node with \(<\text{localPrecondition}\>) for WIP to be identifiable uniquely with ID codes or serial numbers. Items/lots coding system encompasses the OPC numbers as \(i\) where \(i = 1\) to \(n\). Object flows allow specifying the sending token to multiple instances of receivers using \(<\text{multicast}\>) and the receiving tokens from multiple senders by labeling as \(<\text{multireceive}\>) keyword. At Operating process activity regarding the possibility of multiple routings and allocations of operation processes, [Coded (i)] WIP lot is consumed as \(<\text{multicast}\>) input from WIP lot [Coded] \(<\text{centralBuffer}\>) as shown at Figure 9 in details.

WIP lot [Coded (i)] input activity parameter node is connected to expansion node of “iterative” expansion region as \(<\text{multicast}\>). At expansion region Operation process action is taking place on X item [coded (i)] of inputs and produces Y item [Coded (i+1)] as output. Where, X and Y represent the numbers of item usage and item produced at Operation process action and (i+1) represents one operation process performed onto the WIP. The “iterative” mode at expansion region implies the processing is done for all WIP lot/bath with [Coded (i)] one by one till last item in the lot and processed items are stored at \(<\text{centralBuffer}\>) items processed object node. \(<\text{multicast}\>) and \(<\text{multireceive}\>) labels of object flow edges represent the multiple receivers and senders (i.e. operation routings). By every (n) size operation defined by QP instructions, N samples are collected for quality checking through operation staff. Upon undesirable Quality problem acceptEventAction, the exception handler edge executes Fix the problem activity. All tokens from Items processed at \(<\text{centralBuffer}\>) object node are transferred into \(<\text{centralBuffer}\>) WIP lot [Coded (i+1) uncertified] object node through a \(<\text{multireceive}\>) object flow edge. Operation process information is registered into the Operation \(<\text{datastore}\>) leading to Notify QC operation output activity parameter node.

Back to WIP meta-model, the notification is received by Quality department and after Production plan lookup action, Quality operations activity is taking place through collecting M samples output activity parameter node from Operating process activity. QC results data is registered at Quality \(<\text{datastore}\>) and notification results are sent back to Operating process activity and flow of control is terminated as the result of decision node with [OK] guard. Review Quality results and finalizing lot action at Operating process activity consumes all WIP lot with [Coded (i+1) uncertified] \(<\text{centralBuffer}\>) and put all tokens at Certified [OK] output pin node if Quality results are OK. At exceptional situation all tokens are put at Certified [Rejected] output pin node executing Cease production operation action via exception handler edge. In either way, all tokens are directed to activity parameter
Fig. 10: Quality remedy operation activity diagram


nodes of WIP lot [Coded (i+1) QC OK] or WIP lot [Coded (i+1) QC rejected] at exception mode. WIP lot [Coded (i+1) QC OK] is checked using OPC <<decisionInput>> for process progress status through decision node. Work order fulfilled notification signal is sent if all processes are carried out and all tokens are consumed at Finished goods input pin node of Storing process activity at Warehouse. Otherwise, all tokens are transferred into WIP lot [Coded <<centralBuffer>>] again for additional required operations. Eventually, the finished products are stored at warehouse into Stored items <<centralBuffer>> and New inventory [List] is registered into the Inventory <<centralBuffer>> as new records leading to the activity final node.

All tokens of WIP lot [Coded (i+1) QC rejected] as “Exception” outputs at Operating process activity is consumed at Quality remedy operation activity over [Quality rejected] guard of control flow edge as the result of decision node as illustrated at Figure 10.

QC results as input activity parameter node is used at Review the problem and roots action followed by Analyze remedy possibilities and options action and then Analyzing results and remedy solutions is placed at <<centralBuffer>> data object node. Based on Justification for any remedy operation <<decisionInput>> for received WIP lot [Coded (i+1) QC rejected] input activity parameter node, if [Unfixable] then tokens are put at Discard lot output activity parameter node unless [Fixable] then at Segregation activity input pin node. Segregation activity consumes all received tokens and uses Remedy solution data object as inputs. Segregation results data object node as one of its output is used at Registration of Quality remedy data action stored at Quality <<datastore>> and followed by Notification for rework/compensation sendSignalAction directed to Notify re-production output activity parameter. All Segregated products in lots tokens at Segregation activity output pin node are transferred to Segregated products in lots output activity parameter node with <<multicast>> object flow edge.

Back to meta-model, the segregated products in lots are received as another input for Storing process activity at Warehouse into Stored items <<centralBuffer>> and New inventory [List] is registered into the Inventory <<datastore>> as new records leading to the activity final node.

DISCUSSION

Activity diagrams can be used as representation tool for modelling the system behaviour on procedural sequence of operations (i.e. task or sub-process in BPMN) or as describing the whole scenario with series of activities to model the workflow involving several actors or business organizations (i.e. roles in BPMN). BPMN does not render obsolete the need for system modelling development, such as what is performed using the Unified Modelling Language (UML). As explained through modelling development, the flow of material (i.e. physical object) could not been elaborately modelled using BPMN since this standard method simply models the events that occur to start a process, the process that get performed and the end results of the process flow. As it was discussed at business process model for production logistics system, elements of which represent the activities such as receiving goods or deploying resources are modelled as task or events without connectivity objects and there is no possibility to model the flow of a given physical object using BPMN elements. Hence, it is greatly beneficial to demonstrate the flow of material in modelling the logistics system employing UML activity diagrams as supplementary tool for BPMN to provide a
perceptive portrayal of modelling such system which not only helps to understand how it works even to a non-technical users but also it supports the inception of the system received by the business analyst, system architect and software developer absolutely in a better way. Developers can only model part of their applications with UML and as to name exceptions the detailed implementation level is not covered. In contrast, BPMN defines a single type of diagram that has multiple views derived from the same underlying process meta-model. The complementary co-existence of these two modelling methods intends to become the final means of covering the modelling needs.

CONCLUSION

This paper focused on the suitability of BPMN as one eminent standard method on capturing all existing processes. Production logistics as an actual real-world industrial system was modelled and production system was discussed using BPMN. All activities, roles and flows at high domain level been identified. BPMN standard as the main graphical representation of the system provides a high-level analytical business process perspective feature required for a system developers and analysts. However, the need for modelling the physical object flow cannot efficiently be addressed with BPMN in which even in some processes the continuity of object flows act as either instantiation, or resumption of the process. Therefore, UML Activity Diagrams were used to address the problem due to capability of modelling the flow of objects and object semantics. Based on the same identified modelling requirements of Inventory, Quality and Production sub-systems, business process was remodelled emphasizing on the object flow to analyse the whole system. As the result, one main sub-system of Work In Progress emphasizing on the objects and viewing whole system in that perspective provided the significant insights of the system and generated valuable information to address the system requirements for modelling the workflow of material. Among the addressed requirements can be mentioned to the dynamic traceability information of items/lots, actual location, quality control sampling and quality operation instantiation, actual amount of available stocks, raw material and WIP at shop floor are some of the valuable information which are absolutely necessary for system developers and analysts to consider and expect from the models. At the time, the complementary co-existence of these two modelling methods intends to become the final mean of covering the modelling needs on process recognition as well as data and physical object transformations. Moreover, presented business process model provides generic and empirical guideline toward more customized data resource and requirement step at data-modelling for the production logistics system. The useful explanatory description and easy-to-understand strategy and techniques at modelling the business processes is seen as another key feature of this paper which can be followed on modelling identical case and systems. As future work, study over BPMN syntax and semantics on possible additional Artifacts of which could effectively address the object flow issues would be of great value.

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